GREAT SALT LAKE SALINITY ADVISORY COMMITTEE
OCTOBER 12, 2022

Meeting Summary

This meeting was held in person on October 12, 2022 at the Utah Department of Natural Resources with some members attending remotely via GoogleMeet. The following represents a summary of the discussion. It is not intended to represent meeting minutes.

ATTENDEES

Bonnie Baxter/Westminster*
Jennifer Biggs/DFFSL
Thomas Bosteels/GSLBSC*
Phil Brown/GSLBSC (alternate*)
Jeff DenBleyker/Jacobs
Jim Harris/DWQ*
Bill Johnson/UofU*
Krishna Khatri/DWRe (alternate *)
John Luft/DWiR*
David O'Leary/USGS
Craig Miller/DWRe*
Mark Reynolds/USMag (alternate*)
Ryan Rowland/USGS*
Christine Rumsey/USGS (alternate*)
Andrew Rupke/UGS*
Ben Stireman/FFSL*
Kyle Stone/DWiR (alternate*)
Laura Vernon/FFSL (alternate*)
Wade Wallace/GSLBSC

* Salinity Advisory Committee member

OBJECTIVES

A key objective of the Salinity Advisory Committee (SAC) is to advise the State of Utah regarding how the salinity of Great Salt Lake (GSL) can best be managed and, more specifically, how the new Union Pacific causeway bridge may influence lake salinity. The objective of this meeting was to review current conditions in Great Salt Lake and review priorities for research and discussion.

SUMMARY

A quorum was present for the meeting. Jeff DenBleyker opened the meeting with a review of objectives and agenda for the meeting. Jeff reminded the group that SAC meetings are public meetings (per the SAC's charter) and recordings and meeting summaries will be made available for the public. Bonnie Baxter moved to approve the August 4 meeting summary. Thomas Bosteels seconded the motion. The motion carried unanimously.

UPDATE ON SALINITY AND FLOW THROUGH THE CAUSEWAY

Ryan Rowland and Christine Rumsey provided an overview of changing lake elevations, discharge monitoring and salinity trends. Please see the attached slides used in the presentation – preliminary information not for public distribution.

GSL hit a new all-time low water elevation of 4190.1 on July 3, 2022 and has dropped since then to 4189.0 on September 23, 2022. USGS gauge 10010000 became non-operational on September 23 due to the low lake level. USGS Gage 10010024 was installed on the south side of the Union Pacific causeway several years ago and can be used to track current lake levels. On October 11, the lake was at 4188.8; a 2.6ft drop since the April maximum. The lake level very well may continue to drop through October based upon what we have observed in previous years.

Cumulative flows for the Bear River, Farmington Bay, and Weber River were well below the 25th percentile. Cumulative flows in the Goggin Drain were just below the 25th percentile. The estimated total flow for all four of these tributaries was 779,000AF for water year 2022 as compared to 708,000AF for water year 2021. The average annual inflow is 1.9 million acre feet (MAF) for the period of record. Bill Johnson noted that the years of 2012-2016, many of which had the culverts closed, had inflows far below the average annual inflow and yet there was a 3 foot differential in the water levels of the South Arm and North Arm. Thomas Bosteels asked whether anyone has looked at what the required inflow was to maintain a stable lake level. The Brine Shrimp Cooperative has looked at this a bit and estimated that the required inflow was 1.7 MAF. Laura Vernon added that DWRe has estimated that it would take about 600,000 AF of extra water in one year to raise the water level by one foot.

Flows at the new UPRR bridge have changed significantly since the berm elevation was raised in July. The USGS manually measured flows 1, 5, and 12 days after the berm modification was completed and then every 2 weeks. Flows from N-S have dropped off to nearly nothing. Flows from S-N have dropped off to around 300cfs along with a head differential of only about 0.1 feet between the North Arm and South Arm. "Continuous" velocity measurements at the breach also reflect the flow

measurements made by the USGS; however, they illustrate the occurrence of wind events that appear to push water from the north to the south over the berm. Jeff DenBleyker noted that the SAC had previously discussed a concern about an observed reduction in S-N flow when the berm was raised. He pointed out via Ryan's plot that that reduction appears to have coincided with a reduction in the head differential between the North and South Arms; the berm very well may not have reduced that flow by itself. Christine said that measurements to identify the interface between N-S and S-N flows were initially at around 7-8ft below the surface after the berm was completed but have risen to roughly 3.5 ft; this is the same as it was before the berm was completed. The deeper brine layer is not moving but is just sitting there.

The most recent density measurements at Site 3510 in the South Arm were at 180-185 g/L at shallow depths. There is no deep brine layer at 3510 nor at Site 2565. Between no N-S measured flow at the breach and the loss of the deep brine layer at these two sites it appears that raising the berm did exactly what it was hoped to do.

OBSERVATIONS BY OTHERS

Craig Miller noted that his team had gone with Christine Rumsey to look for leaks through the old culverts in the UP causeway by looking for high salinity flows. He said that the elevation of the lake bed at the culvert was about 10 ft higher than expected, perhaps due to the weight of the causeway. They did find the deep brine layer but the salinity was not similar to the North Arm and there was a lot of sediment that would have prevented North Arm flow from reaching that sampling point. They concluded that there was no flow through the old abandoned and plugged culverts – but where is the salt coming from?

Jeff DenBleyker asked how much salt mass is exceeding what we would expect. Craig said that it is a significant number; if we cant model it then we cant use our models to forecast the future. Bill Johnson asked if there was enough of a head differential between the North and South arms to drive flow through the causeway fill. Craig said that the 3.2ft difference when the causeway was plugged indicated that there was very little if any flow going through the causeway. Ryan Rowland said that USGS has a remotely operated submarine that might be able to be used to look for North Arm water flowing through the causeway. Dave Naftz had previously used a fiber optic temperature cable to look for temperature anomalies on the south shore of GSL; we do not expect there to be a temperature differential between North and South arm waters.

RESEARCH / MONITORING FRAMEWORK

Jeff DenBleyker provided a brief introduction, a review of the SAC's progress with the research plan, and a review of new questions identified by the SAC (see attached slides, red check marks reflect work is completed, orange check marks reflect work that is underway). Points of discussion were as follows:

- Andrew Rupke explained that UGS has previously had challenges with getting consistent ion composition results from laboratories for GSL waters. The intent is to complete a laboratory round robin to identify the best laboratory method.
- Bill Johnson asked if there is a central repository for GSL documents and data. Laura Vernon said that this has been discussed for a long time; there is not currently a central repository. Laura would like to see the idea advanced. Andrew said that UGS has an online repository for documents that could potentially be used ("open file reports"). Ben Stireman suggested that this might be an important effort to push forward this year.
- Bill Johnson noted that while we might not see the deep brine layer, it dissipated into the water column. Has the evolution of the deep brine layer been documented? We need an overview of what has happened since the culverts were closed. Christine Rumsey noted that USGS is working on a summary that should address that.
- Are mineral extraction companies flushing salts back into the lake that counteract what we are trying to do at the breach? Craig Miller explained that it is estimated that they are extracting about 5 million tons per year and returning about 3 million tons per year. This does not explain the observed increase in salt mass in the South Arm.
- Christine explained that USGS' measurements are monthly, and the lake is extremely dynamic. There is a lot going on in between measurements but monthly is the best we can do right now. Using the available data, we can estimate the salt mass going through the breach; there is more being exported to the North Arm than is being imported to the South Arm. USGS is working with Dr. Som Dutta to develop a model that can allow the USGS to estimate a daily discharge based upon velocity measurements.
- Thomas Bosteels summarized that one hypothesis is that the increasing salt mass could be from saltwater springs into the lake. Another hypothesis is that we have challenges with measurement methods. Christine agreed, there is a blanking distance near the bottom of the channel. Ryan Rowland explained that the USGS has purchased a new uplooking meter to improve these measurements but there is still a blanking distance. The USGS is measuring the velocities in the blanking distance with spinning cup device to better understand that. Ryan agreed that there is uncertainty in our measurements. We are trying to tighten that up but also trying to determine if there are other sources of that salt.

- Bonnie Baxter said that she has been talking to Jack Oviatt about his work at the Bonneville salt flats. He has postulated that some of the salts may be coming in via groundwater rather having been previously deposited at the surface by Lake Bonneville. Perhaps this might be a contributing factor for GSL? Ben Stireman wondered if there were industrial water uses pumping groundwater in the west desert that might be able to help answer that question.
- Bill Johnson suggested that the deep brine layer is a dynamic feature; perhaps that is a source of error. Christine agreed that we are extrapolating the location of the DBL from just a few measurements.
- Andrew suggested that it would be helpful to provide a very brief summary of what was learned by each of the studies developed to answer the SAC's questions.
- Jeff suggested that studying the ion composition of GSL may be important in evaluating impacts to the biology but also in evaluating proposals such as importing ocean water. Bonnie Baxter noted that the ions in Great Salt Lake should mimic the ion composition of the ocean. GSL is a thalassic lake with similar proportions of salt as the ocean.
- Bill Johnson wondered about the effect of cutting off the North Arm. Craig Miller said that if we close the breach, it might raise the South Arm by a foot or two over a few years. Bill suggested that we already did this experiment when we closed the culverts. We closed the culverts on low water years and the South Arm was up 3 feet. Andrew asked whether the causeway could function as a dam. Mark Reynolds said that it has moved in the past. Craig noted that closing the breach will have an impact upon the North Arm. Others noted that a half a lake may be better than no lake; perhaps there are options to help Compass get water from the South Arm. Ben Stireman said that there might be a Section 404 permitting problem because the existing permit requires that the opening remain open.
- Someone pointed out that Compass may already be extracting water from the South Arm. Ben clarified that this canal is used to get water used to flush their pumps.
- Thomas suggested that all of these questions are important in the long term but we are facing a crisis. The lake is on its way to 22% salinity; the Aral Sea is at that level and they have lost their brine shrimp population. Shouldn't we try to identify the priority questions? We may not have time to develop all of the information we need to make decisions. What is the amount of water that is needed to maintain lake levels? The Brine Shrimp Cooperative estimated about 400,000 acre feet but that is a question that modelers should address. How can we get water to the lake? How much do we need?
- Craig agreed that there are many things that we could and should look at. There may be other options that should be evaluated. Thomas agreed. Perhaps we could put in a dike from Carrington Island to the UP causeway. Craig added that a very important question is how much evaporation is actually occurring. That will help determine how much water is needed.

Priority Questions

Jeff DenBleyker asked the SAC to consider what the key questions are that we must answer right away. The Legislature and Division of Water Resources are working on how to get water to the lake. Jeff asked the committee to focus upon what is going on in the lake; namely, changes in salinity. Bill Johnson suggested that an important question is to determine how to best optimize the water that actually gets to the lake. How can it be used to protect and benefit the maximum number of beneficial uses? Jeff asked the SAC to consider what options we have. If we can identify options, then we can use what we know and the tools we have to evaluate whether they can help or hurt.

Craig Miller said that DWRe has already been looking at many different options. With the poor inflows we have had since 2016, cutting off the North Arm may only raise the South Arm by 0.5 feet. That seems low and needs to be reviewed but it is a start. There are many factors that need to be considered. Kyle Stone said he has heard suggestions to close off the causeways for Farmington Bay and Bear River Bay both to reduce dust emissions but also preserve the wetlands in those areas. We need to get these ideas on the table so that we can evaluate them and they can be crossed off the list or considered further. These results can then be used by policymakers to make decisions.

Bill asked if DFFSL could use some of these ideas for Hot Topics grants. Laura Vernon said that they definitely could and would.

Andrew Rupke asked Jeff to clarify the scope of what the SAC is doing. Is the SAC just focused upon in-lake options? Jeff said yes. There are many groups already looking at the watershed options. This committee could provide the most value by focusing upon the lake itself. Bill added that if the situation persists, what can we do? We need to prioritize our questions so that we can get to the most favorable outcome possible.

ACTION ITEMS

1. Jeff will summarize the key ideas that were raised at the meeting today and send that to the SAC for review.
2. The SAC will send any new ideas to Jeff by October 20. What are the options to protect and preserve the lake itself?
3. Jeff will summarize the ideas and send them back to the SAC for review. These can then be the basis for identifying the science gaps that must be addressed to evaluate the options.
4. The SAC will then review and come to the next meeting prepared to discuss and prioritize.

Next meeting: November 3, 2022, 1-3pm.

USGS
science for a changing world

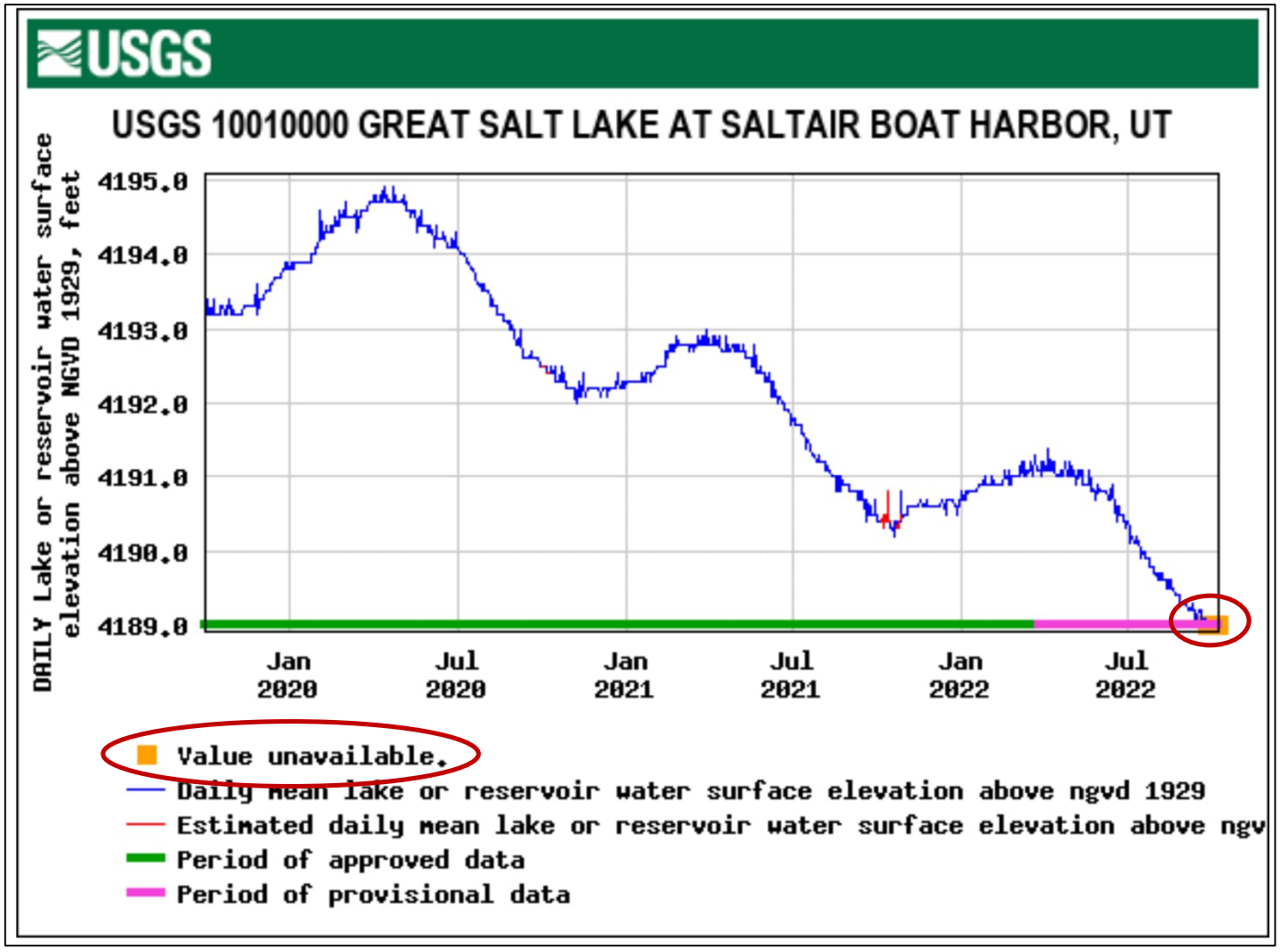
Great Salt Lake Update

View from Gilbert Bay, Great Salt Lake, October 2018

Discussion Topics…

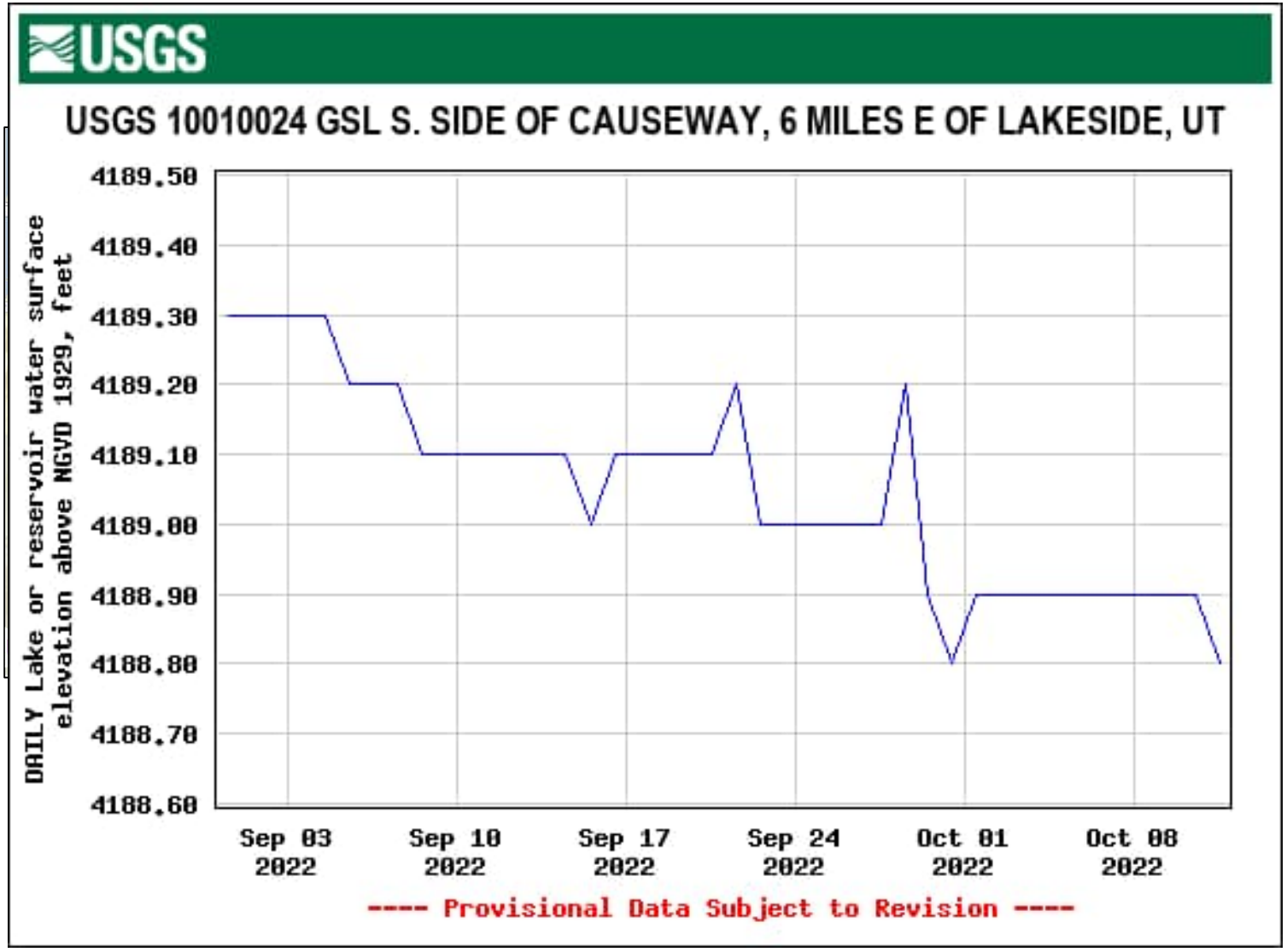
- **Lake elevation and discharge/velocity data**
- **Salinity update**

Lake Surface Elevation



Preliminary information-subject to revision.
Not for citation or distribution.

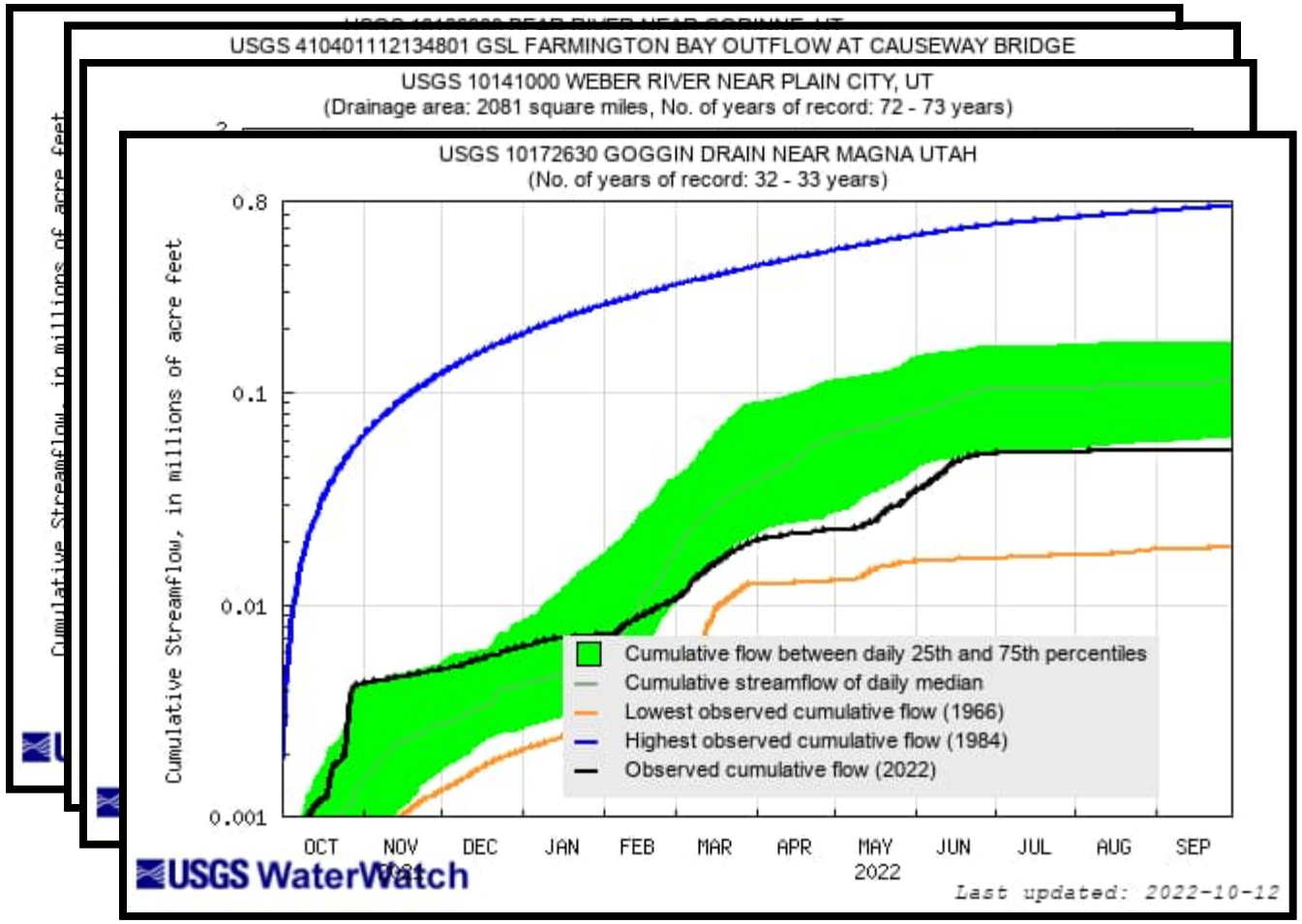
Lake Surface Elevation



- Daily value on 10/11/22 = 4,188.8’
- 2.6’ drop since April max.

Preliminary information-subject to revision.
Not for citation or distribution.

Major Surface Water Inflow Rivers



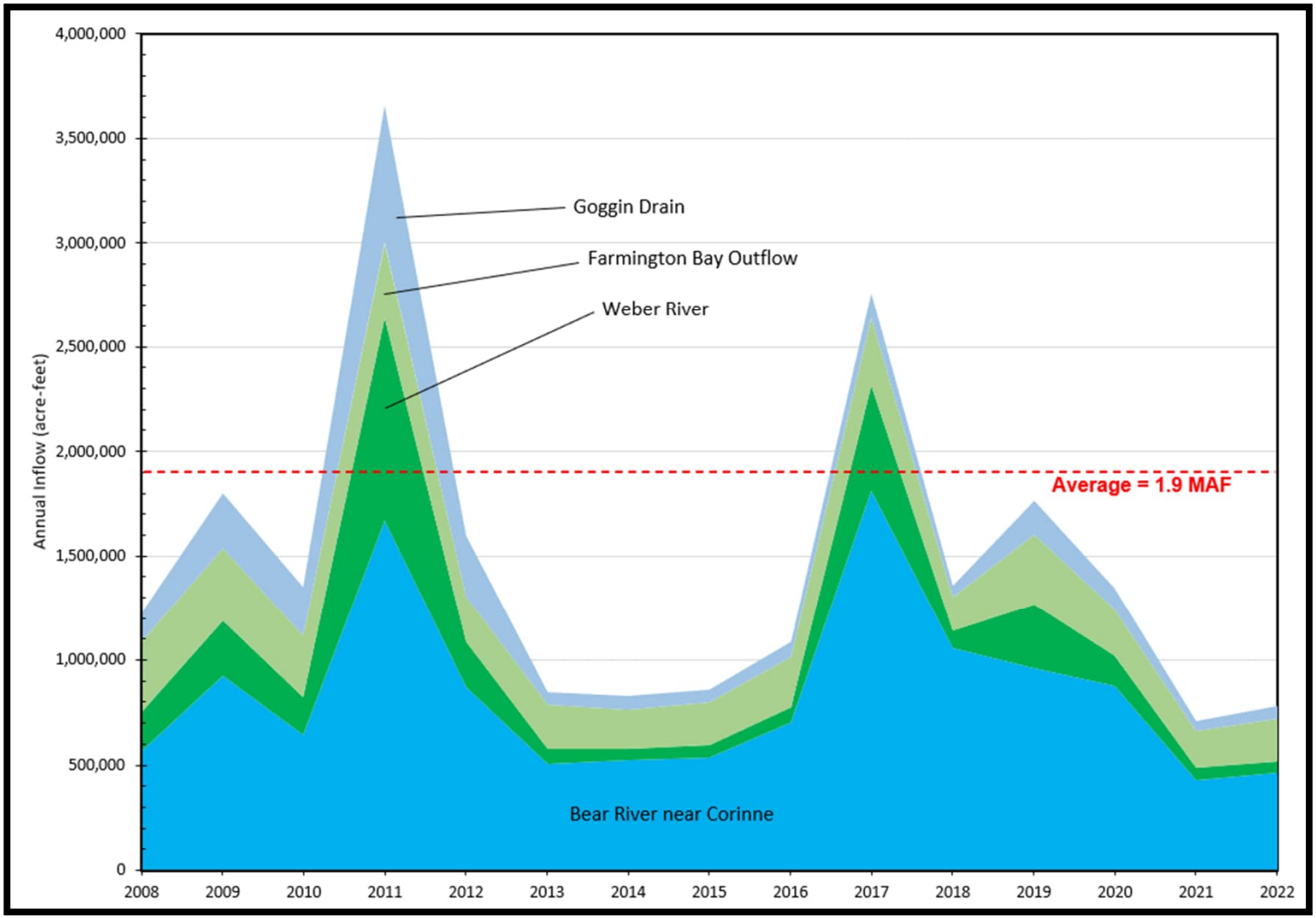
Total:

- **WY2022 = 779,000 AC-FT**
- **WY2021 = 708,000 AC-FT**

Preliminary information-subject to revision.
Not for citation or distribution.

USGS
science for a changing world

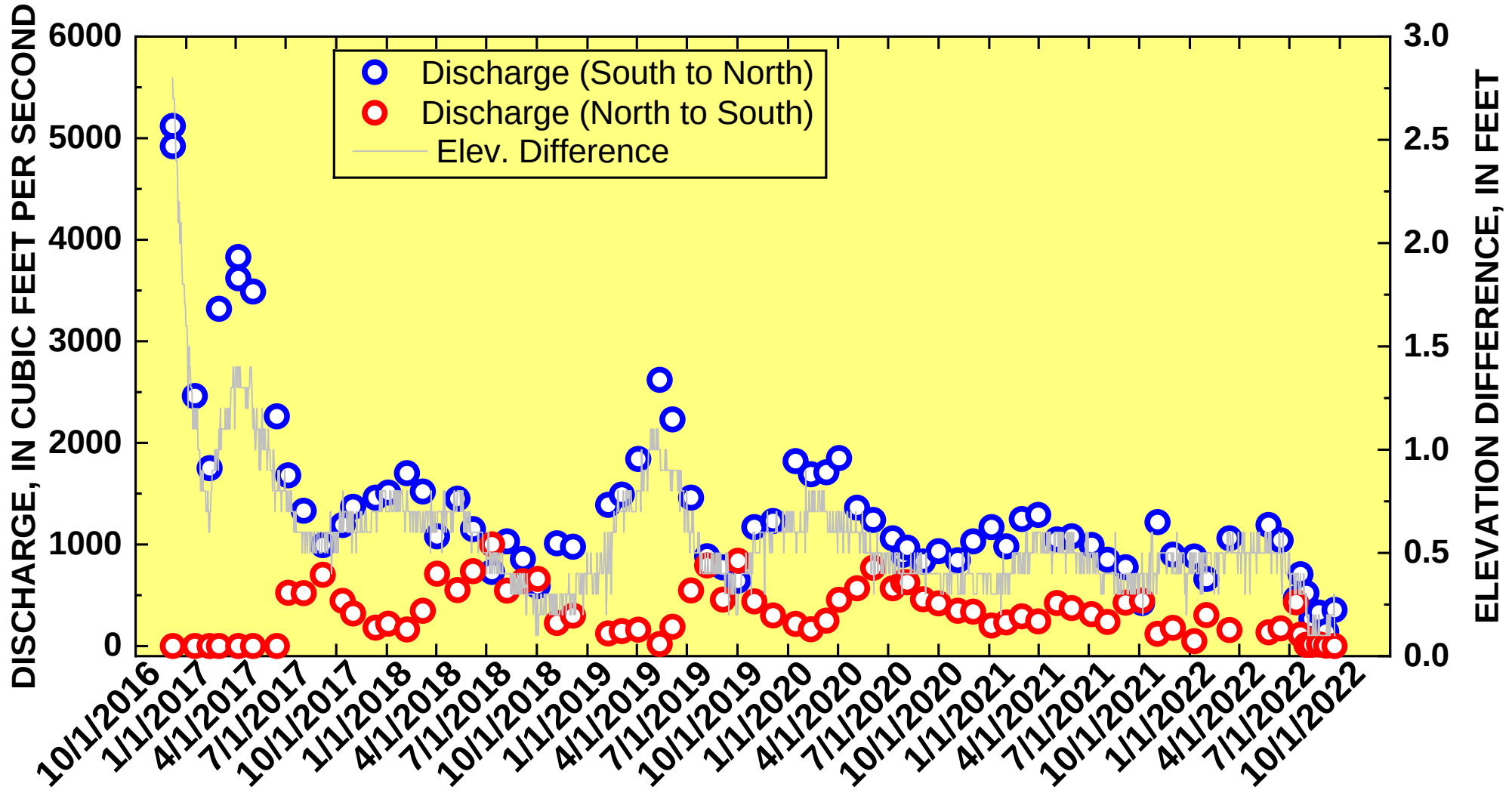
Major Surface Water Inflow Rivers



Preliminary information-subject to revision.
Not for citation or distribution.

USGS
science for a changing world

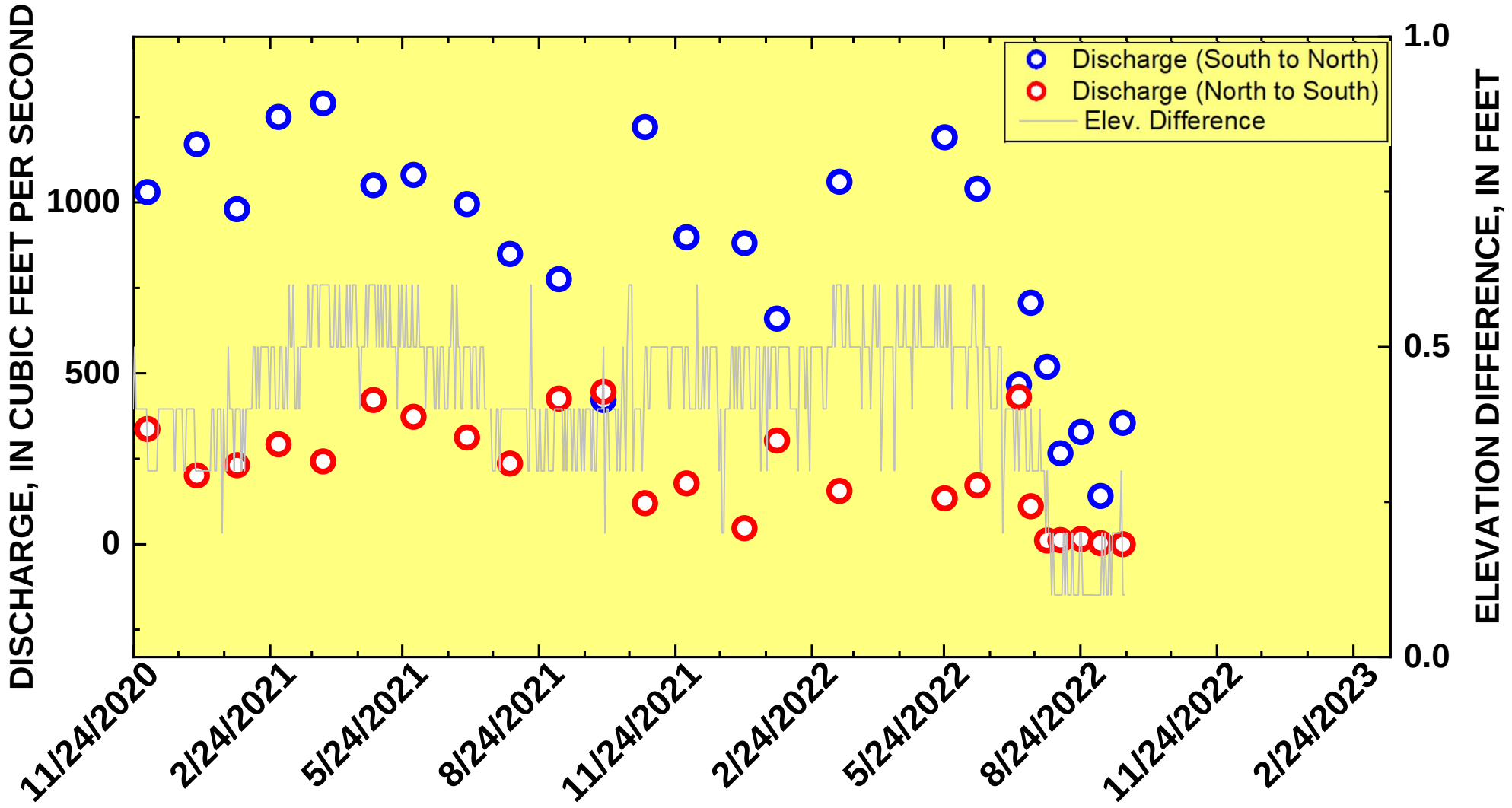
New Breach Flows



Preliminary information-subject to revision.
Not for citation or distribution.

USGS
science for a changing world

New Breach Flows

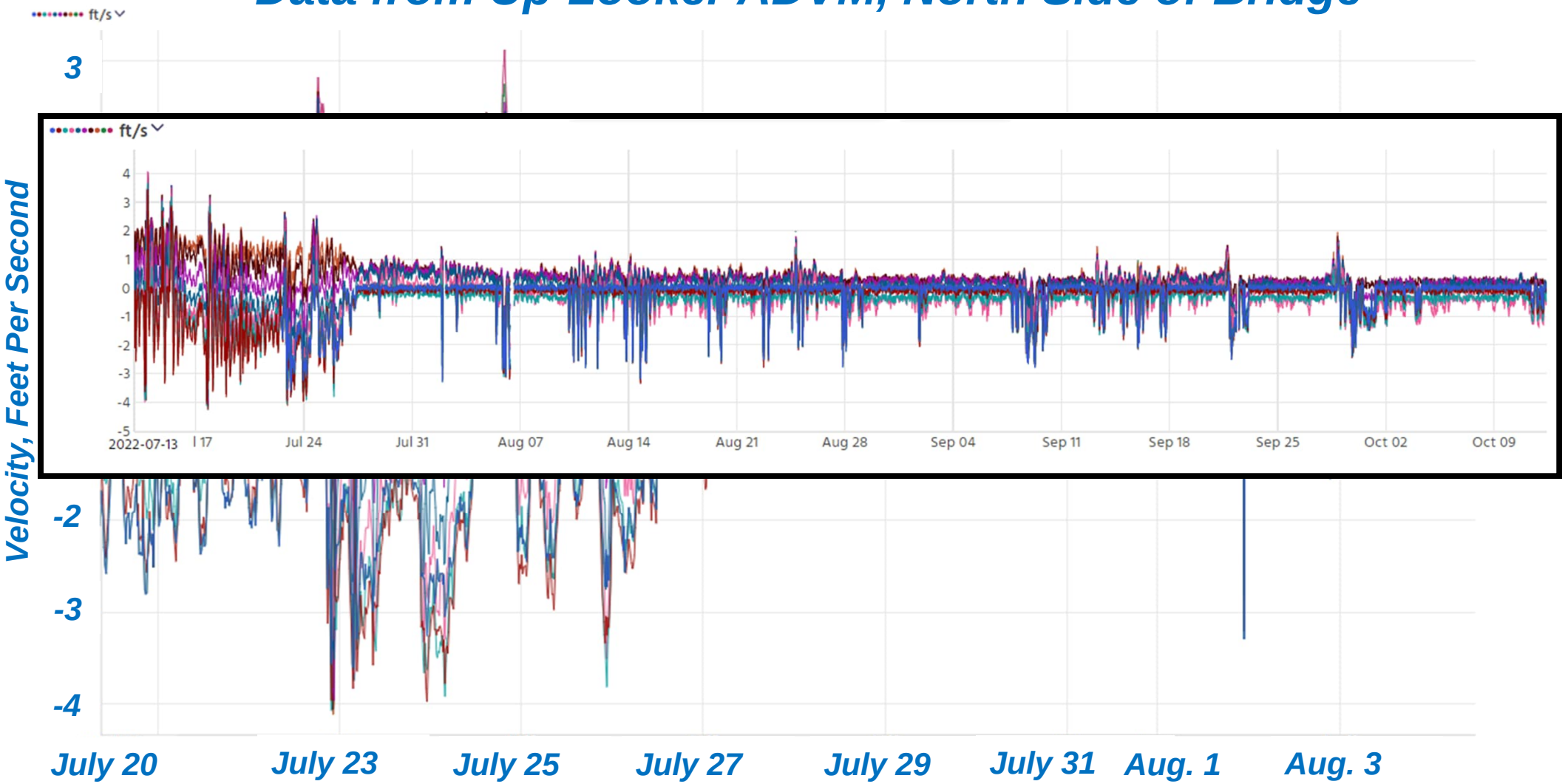


Preliminary information-subject to revision.
Not for citation or distribution.

USGS
science for a changing world

New Breach Velocity Data

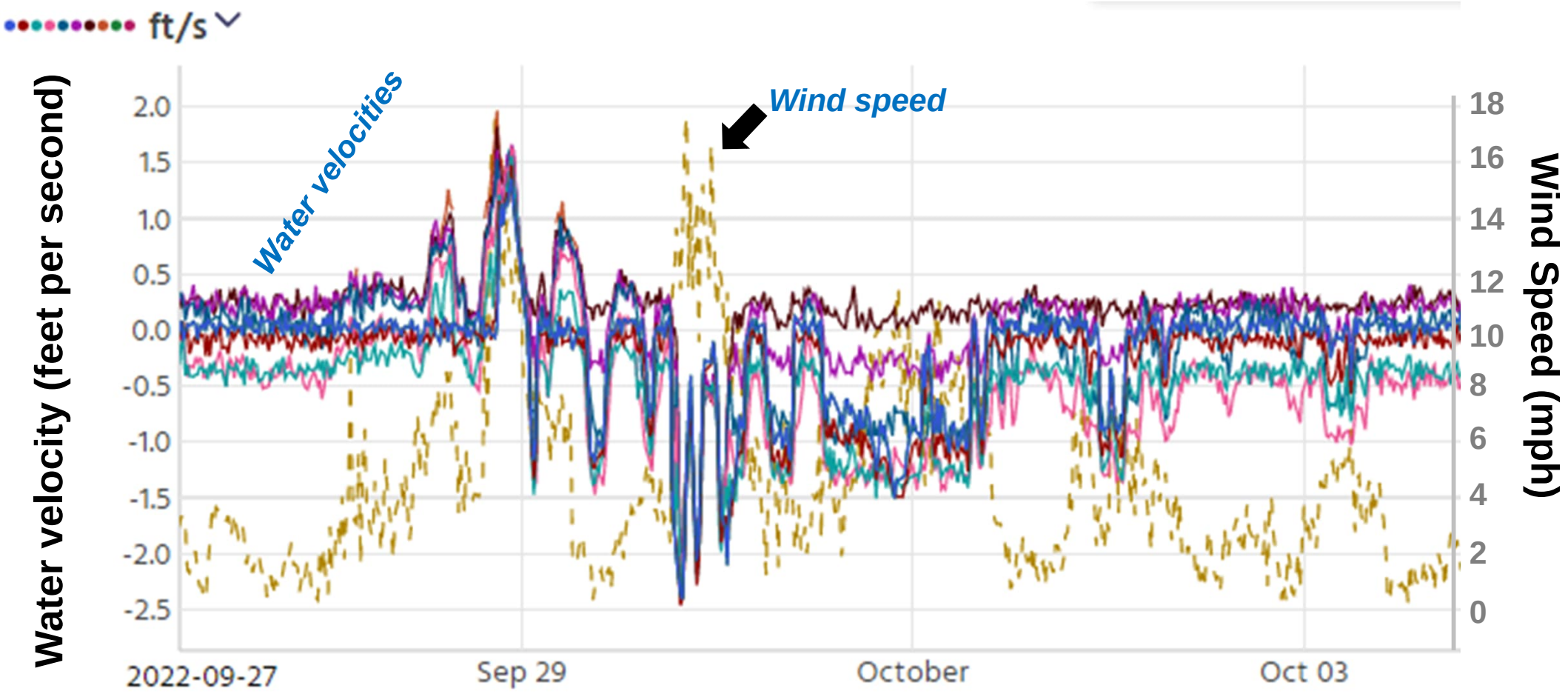
Data from Up-Looker ADVM, North Side of Bridge



Preliminary information-subject to revision.
Not for citation or distribution.

USGS
science for a changing world

New Breach Velocity Data



Preliminary information-subject to revision.
Not for citation or distribution.

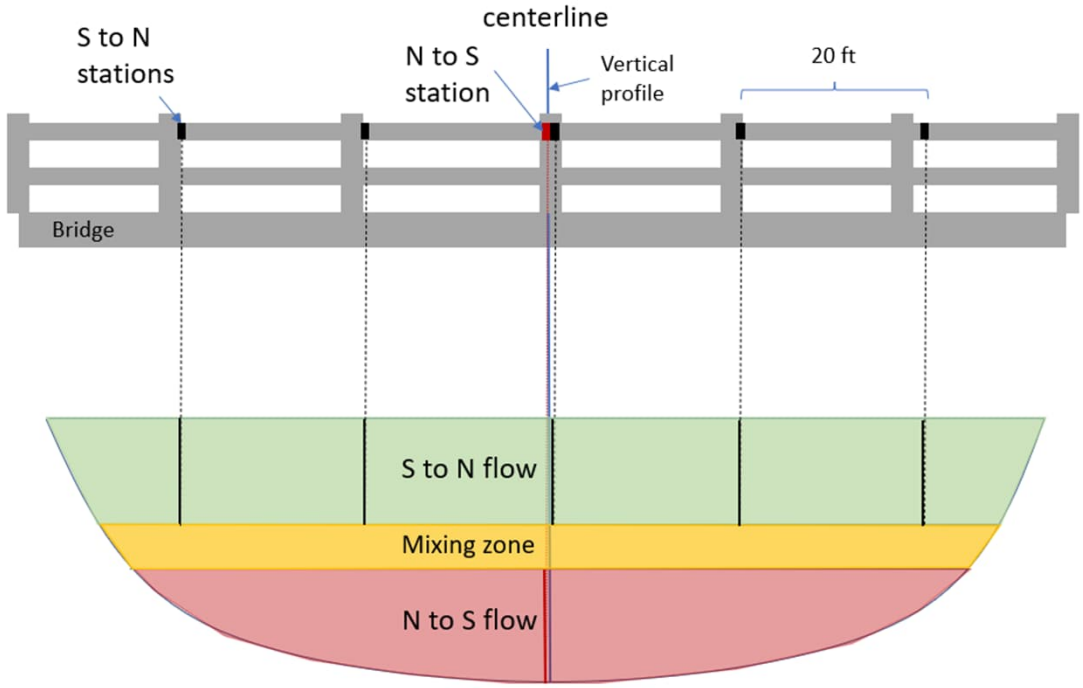
New Breach Monitoring after Berm Modification

- Increased monitoring frequency in response to berm modification
  - 1, 5, and 12 days after
  - Then every 2 weeks
- Measuring discharge, velocity profiles, and water quality parameters

Modified berm north of causeway, 7-29-22

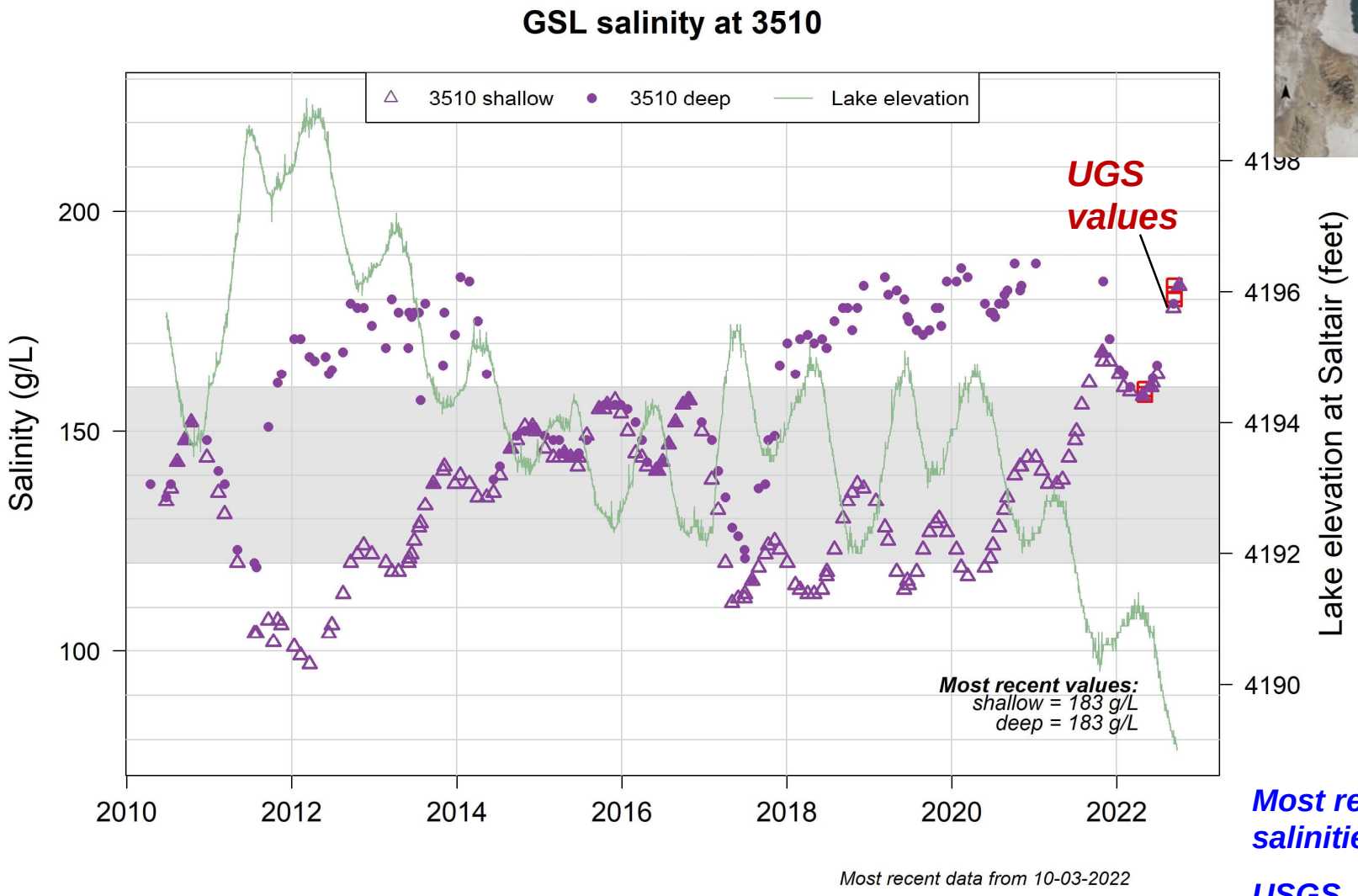
Profiles after berm modification indicate presence of stagnant North Arm plume

Sample date	Depth to top of interface (ft)
7/22/2022	3.5
7/28/2022	Berm modification complete
7/29/2022	7.9
8/2/2022	6.8
8/11/2022	5.2
8/25/2022	7.2
9/7/2022	6.8
9/22/2022	3.5



Preliminary information-subject to revision.
Not for citation or distribution.

Current conditions: Salinity at 3510



Most recent data from 10-03-2022

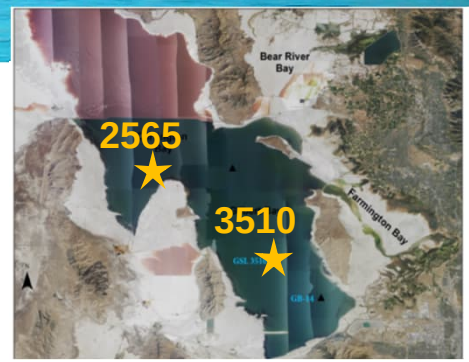
Most recent shallow salinities

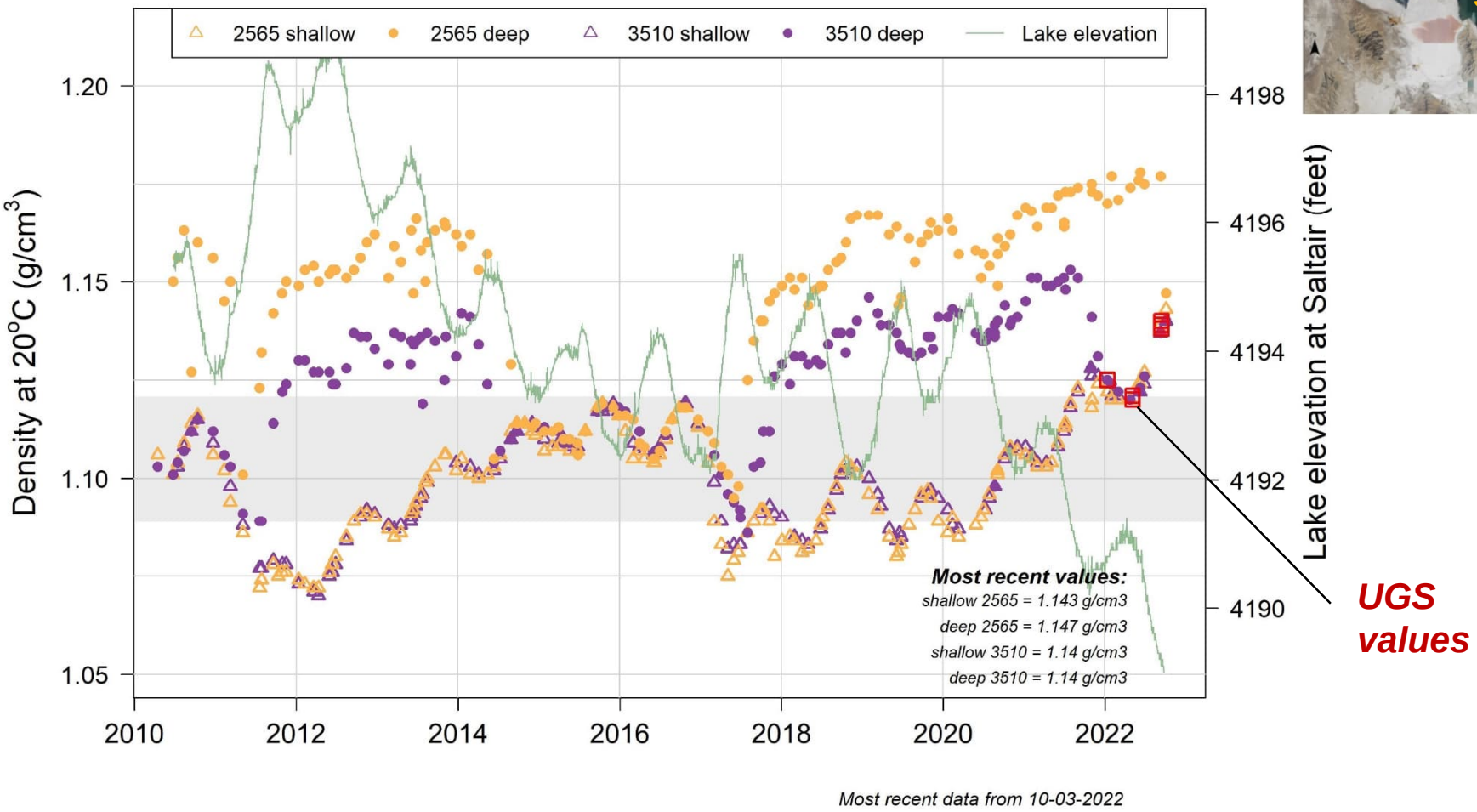
USGS, 10-6-22, 180-185 g/L

UGS, 10-11-22, 184-185 g/L

Preliminary information-subject to revision.
Not for citation or distribution.

Current conditions: Density at 3510 and 2565





UGS values

Preliminary information-subject to revision.
Not for citation or distribution.

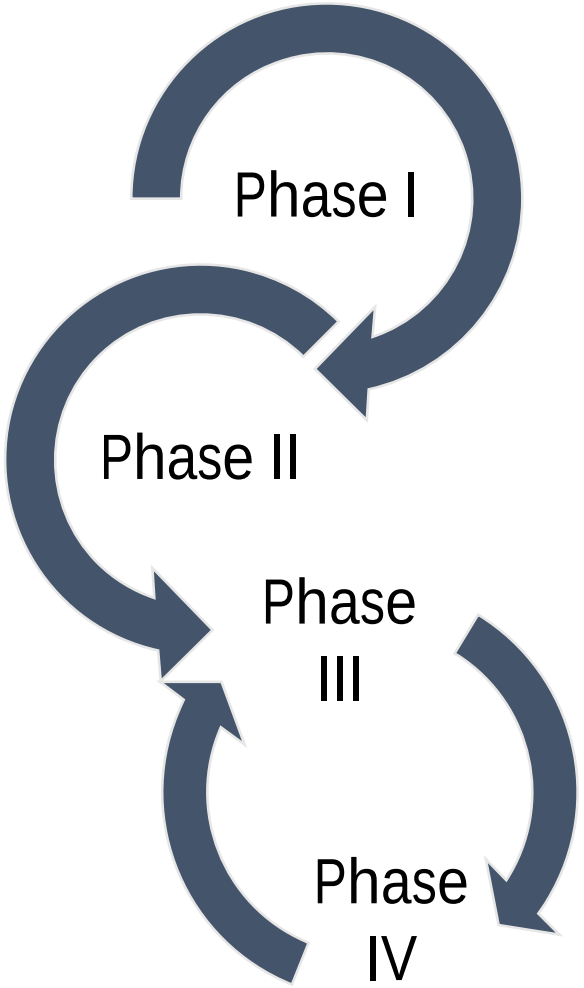
Great Salt Lake Salinity Research/Monitoring Framework

Great Salt Lake Salinity Advisory Committee

(Updated October 12, 2022)

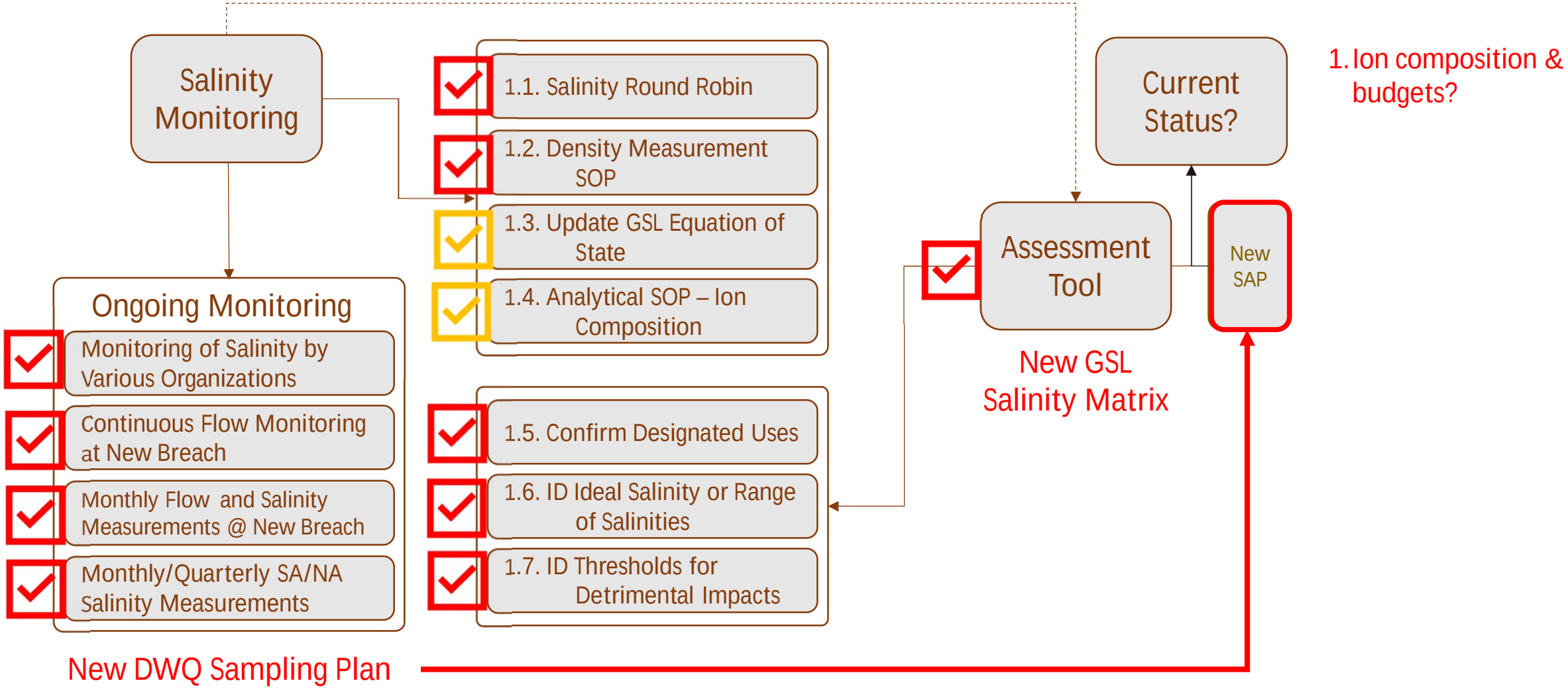
Phased Approach

- Phase I – Are we using the correct methods and thresholds? Is our current condition ok?
- Phase II – What key salinity characteristics and dynamics drive the system and how?
- Phase III – Can and how should salinity be managed into the future?
- Phase IV – How could and do watershed and lake level changes affect the salinity?



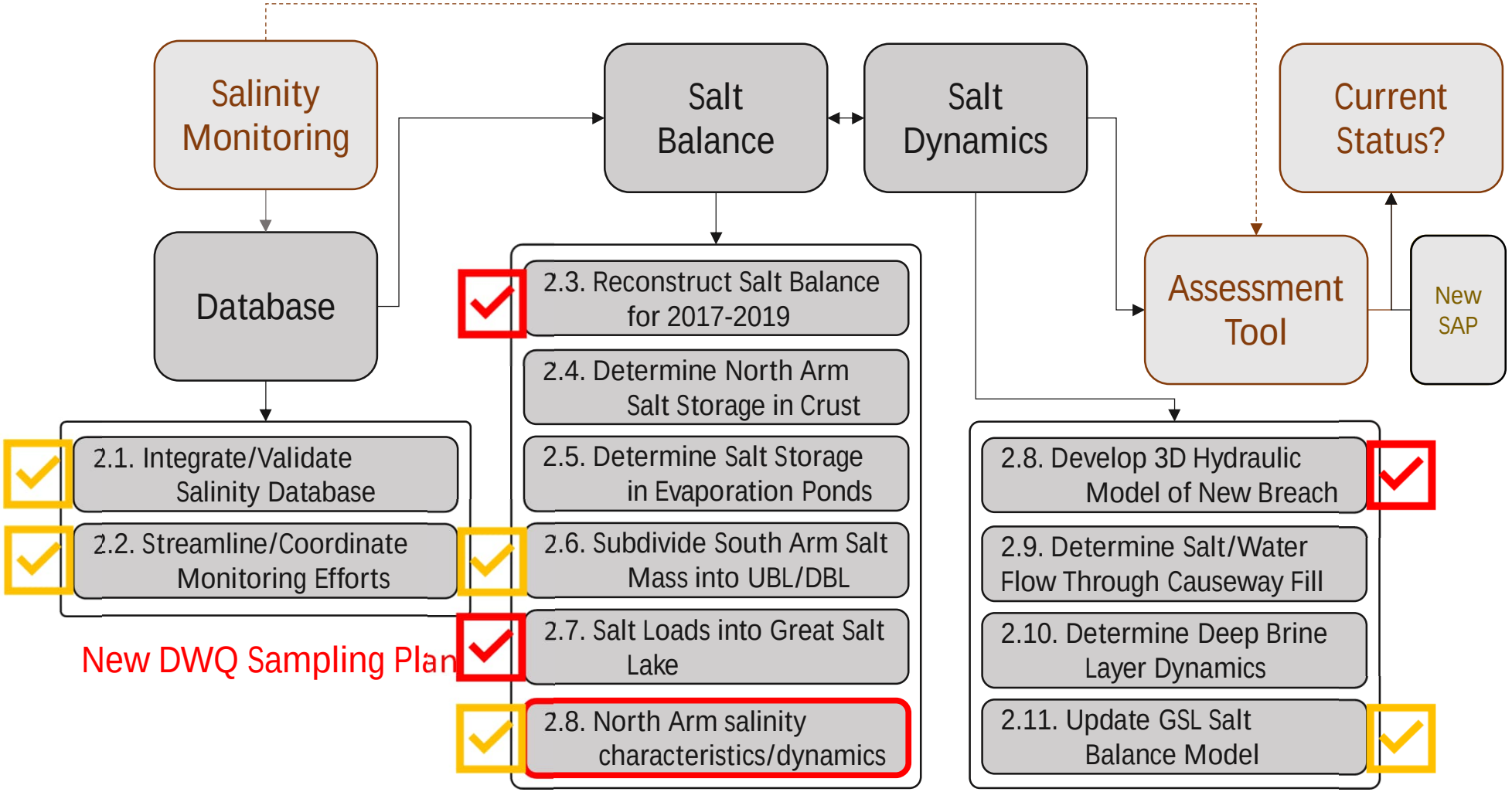
Salinity Research Framework – Phase I

Are we using the correct methods and thresholds? Is our current condition ok?



Salinity Research Framework – Phase II

What key salinity characteristics and dynamics drive the system and how?



1. Where should future data reside?
2. North Arm salinity dynamics/characteristics?
3. South Arm salinity mass balance?
4. Flow through causeway fill
5. South Arm deep brine layer dynamics?
6. Areal South Arm salinity dynamics?
7. Salt precipitation processes
8. What can we learn from historical shifts?

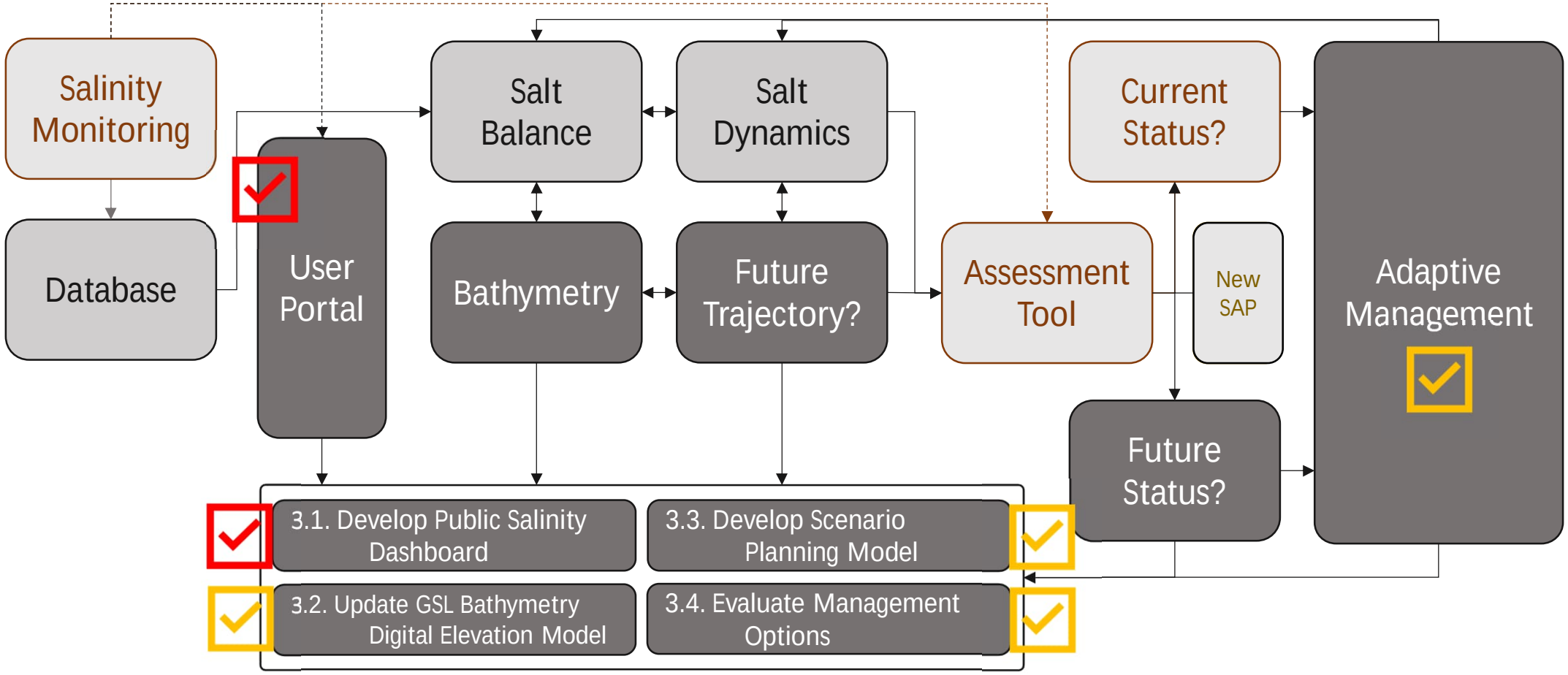
Salinity Research Framework – Phase III

Can and how should salinity be managed into the future?

- How can we integrate these processes?
- Which factors have the most influence? At what time-scale?
- How might salinity change into the future?
- How can we manage in-lake salinity?
- How does saltwater removal influence salinity (removing salt & water)?
- Should something be done about the deep brine layer?

Salinity Research Framework – Phase III

Can and how should salinity be managed into the future?



Salinity Research Framework – Phase III

Can and how should salinity be managed into the future? What are the implications?

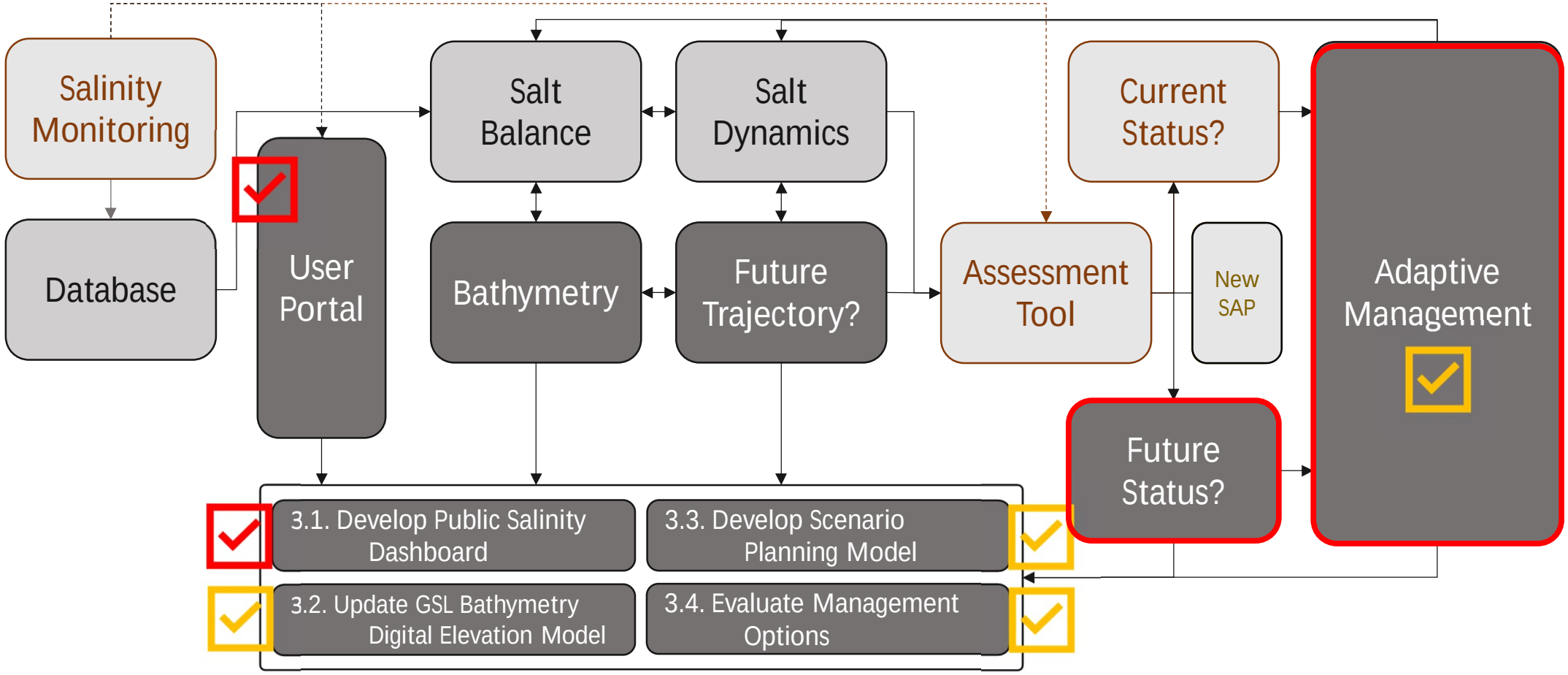
- How can we integrate these processes?
- Which factors have the most influence? At what time-scale?
- How might salinity change into the future?
- How can we manage in-lake salinity?
- How does saltwater removal influence salinity (removing salt & water)?
- Should something be done about the deep brine layer?

Pacific Ocean proposal?

- What are the implications to designated uses if we change paradigms (ecology, mineral extraction)?

Salinity Research Framework – Phase III

Can and how should salinity be managed into the future?



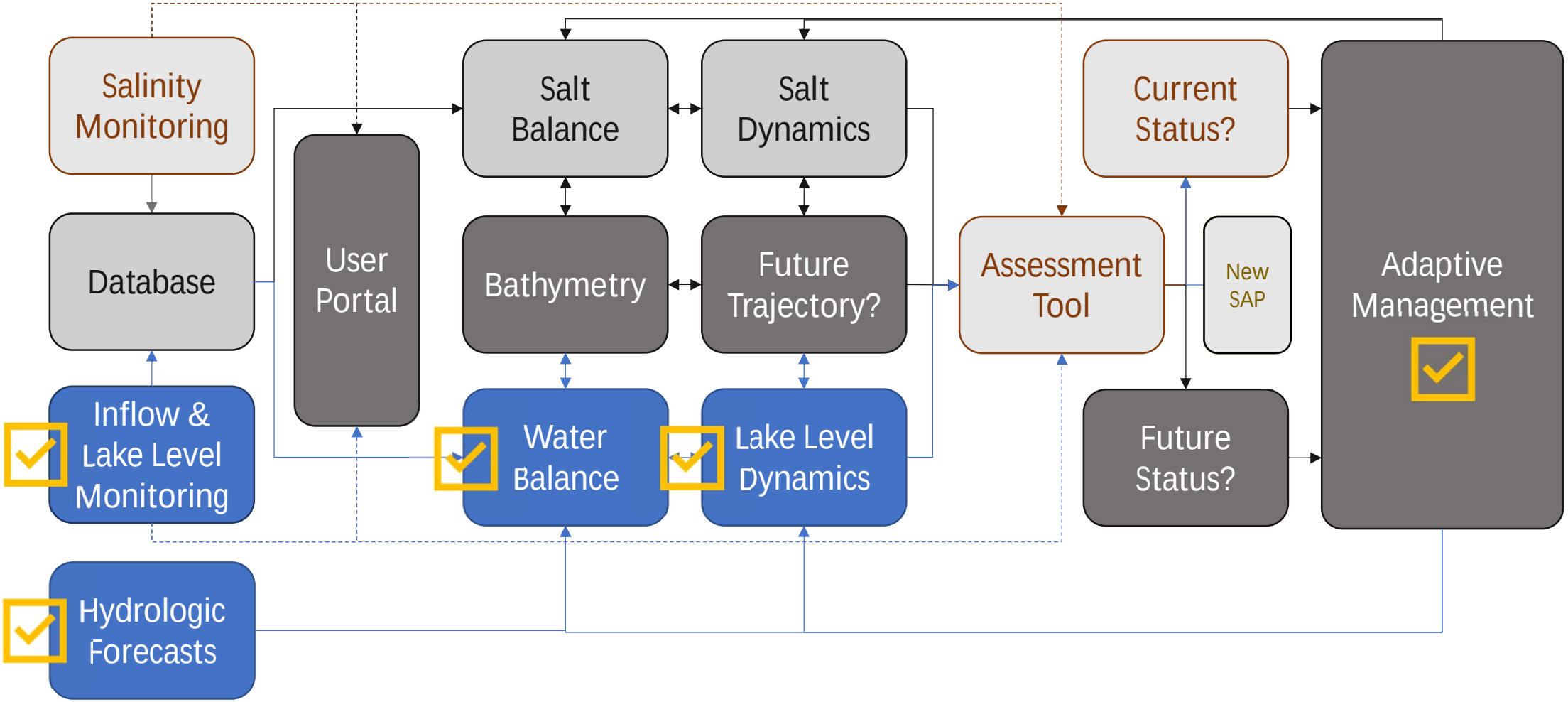
Salinity Research Framework – Phase IV

How could and do watershed and lake level changes affect the salinity?

- How can we integrate these processes?
- Which factors have the most influence? At what time-scale?
- How might salinity change into the future?
- How can we manage in-lake salinity?
- How does saltwater removal influence salinity (removing salt & water)?
- Should something be done about the deep brine layer?
- How do reductions of inflow influence salinity?
- What happens if lake levels come back up?
- What are the implications to designated uses if we change paradigms (ecology, mineral extraction)?

Salinity Research Framework – Phase IV

How could and do watershed and lake level changes affect the salinity?



Misc topics that didn’t fit into the above

- Where does Farmington Bay and Bear River Bay fit into this?